Chapter 9

Odontological Indicators of Disease, Diet, and Nutrition Inadequacy

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The dentition is usually the best-preserved element of the skeleton. Hydroxyapatite, an inorganic calcium matrix, comprises approximately 97 percent of the chemical composition of enamel (Carlson, 1990). This crystalline structure makes dental enamel hard and dense and useful to resist the abrasive nature of mastication. Also, as a result of their hardness, teeth are often all that remains of a long-deceased individual. The abundant presence of dentition in archaeological contexts has led to the intensive exploitation of teeth for information about the past. Chapters 8 and 6 of this report have addressed the systemic effects of nutrition in dental development and of ecosystem relationships that changed dental chemistry, respectively. In addition, the relative presence or absence of pathological conditions, such as tooth loss, caries (cavities from dental decay) and associated abscesses of the alveolar bone surrounding the dental root and cervix also provide evidence of the general level of biological well-being and accessibility of dental care, as well as biological effects of foods commonly eaten.

In order to further understand the diets and living conditions of individuals from the African Burial Ground (ABG), in this chapter, we summarize traditional odontological methods for assessing the local effects of different foods within the oral cavity itself. We specifically focus on dental caries, dental abscesses, and tooth loss. Subsections include discussion of the frequencies of subadult and adult dental diseases as well as the differences found in adult males and females. Finally, comparisons of

infectious dental pathologies (caries, associated abscesses and antemortem tooth loss) will be made between the ABG population and other skeletal samples that may have experienced similar life conditions. We also briefly discuss a few cases of micro and macrodontia.

Sampling

For a variety of reasons, sample sizes for each pathological observation will vary. Much of the variation centers on not only the relative state of preservation of the teeth, but also the condition of the surrounding alveoli. In many cases, teeth were recovered while the surrounding alveoli were too poorly preserved for observations of pathology. Likewise, many dentitions were part of, and encased in, cranial pedestals, often obscuring a complete side of the dental arcade in cases where teeth were too friable to remove in an observable state. Additionally, many teeth were covered with organic or diagenetic staining due to the local soil conditions, water seepage and damage, and the time elapsed since interment (Figure 9.1**)**. This discoloration is not to be confused with enamel hypocalcification; it often affects dental roots and the surrounding alveoli which were exposed as a result of postmortem deterioration, as well as dental enamel. Calculus deposits built up on tooth surfaces, and although these deposits were usually removed, calculus sometimes prevented pathological observations.

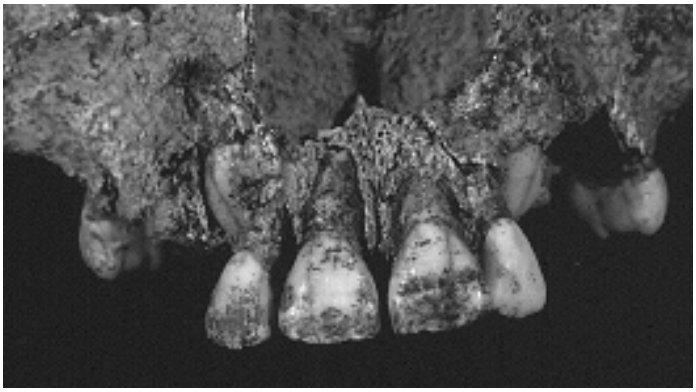

Figure 9.1: Diagenetic staining affecting dentition in a 55 – 65 year old female (Burial 241)

Finally, antemortem tooth loss and traumatic fractures, especially of the molars, precluded some diagnoses, and in the cases of the twenty six individuals exhibiting dental modification, along with enamel being lost due to filing/chipping, some pathology information was lost as well **(Appendix 9.1).**

After the skeletal remains of each burial were cleaned and reconstructed, the dentition for each burial (permanent and or deciduous) was cleaned, identified, assessed and curated separately by the Laboratory Director and his assistants. Data collection was performed under the guidelines set forth in *Standards for Data Collection for Human Remains* (Buikstra and Ubelaker 1994). Pathological recordation for the deciduous and/or permanent teeth included dental inventories and tooth loss with alveolar resorption, caries reporting by surface and number of caries by tooth, abscess presence and location (buccal, lingual or exudative), and other pathological observations (molar agenesis, dental crowding, etc.) (Appendix 4.6). Dental caries is defined as a progressive tooth demineralization resulting from localized fermentation of food sugars and carbohydrates by bacteria (Mandel, 1979). Dental caries formation, periapical abscessing and antemortem tooth loss are all evidence of a disease process (Larsen, 1997). A complete

photographic record was constructed for each tooth, the overall dentition and the maxillary and mandibular alveoli (Figure 9.2).

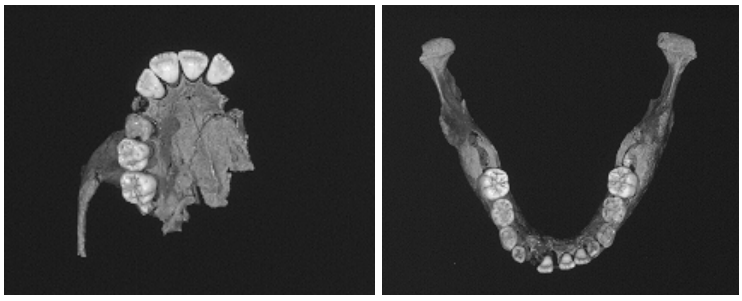

Figure 9.2: Examples of the photographic record (Burial 95, a subadult aged 7 – 12 years)

For example, the plate on the left displays the occlusal surface of the maxillary dentition and alveoli, while the plate on the right provides an occlusal view of the mandibular dentition of Burial 95, providing photographic evidence of dental observations.

Only dentitions from individuals with known sex and age (both adult and subadult) are used for the following dental pathology analysis. For these purposes, adults are defined as 15-60+ years of age, while subadults are defined as younger than 15 years (14.99 and below). The rationale supporting these definitions and the use of only individuals with known sex and ages has been outlined above (Chapter 7). It is a bit troublesome to have multiple definitions of "adulthood" – one for demographic purposes and another for other studies.

Infectious Pathology

Tables 9.1 and 9.2 contain, respectively for males and females, dental pathologies – caries and abscesses – frequencies identified in the New York African Burial Ground (NYABG) sample. Caries is present in all tooth types. However, as expected the highest frequencies of caries are found in molars followed by premolars and single cusped incisors and canines. The highest frequencies found in males are in the lower left first molar (37.74 percent), the lower left second molar (31.03 percent), and the upper right third molar (30.43 percent). The least carious tooth is the right lower second incisor (2.67 percent). No tooth type is caries free. Whereas just three teeth reached caries prevalence of over thirty percent in males, thirteen teeth reach a similar threshold in females, including eleven of twelve molars and two premolars. As it did in males, the lower left first molar displays the highest frequency of caries in females (55.17 percent).

The prevalence of dental abscesses is also greatest in molars. In males, the highest prevalence of abscessing is found on the upper right first molar (19.70 percent) followed by the contralateral upper left first molar (17.19 percent). Interestingly, in females, the highest frequency of abscessing is found in the lower left first molars (24.14 percent) and right first molars (18.75 percent).

Table 9.1: Dental Pathology Frequency - Males – Permanent Dentition

Tooth #	Present	Absent	Total	% Absent	# Caries	% Caries	# Abscess	% Abscess
1) RM^3	69	8	**77**	10.39%	21	30.43%	7	10.14%
2) RM^2	68	9	**77**	11.69%	17	25.00%	7	10.29%
3) RM^1	66	15	**81**	18.52%	19	28.79%	13	19.70%
4) RP^2	71	9	**80**	11.25%	14	19.72%	8	11.27%
5) RP^1	73	10	**83**	12.05%	17	23.29%	8	10.96%
6) RC^1	77	5	**82**	6.10%	11	14.29%	1	1.30%
7) RI^2	72	6	**78**	7.69%	9	12.50%	0	0.00%
8) RI^1	70	10	**80**	12.50%	10	14.29%	1	1.43%
9) LI^1	71	8	**79**	10.13%	10	14.08%	3	4.23%
10) LI^2	75	8	**83**	9.64%	7	9.33%	2	2.67%
11) LC^1	72	8	**80**	10.00%	12	16.67%	5	6.94%
12) LP^1	64	13	**77**	16.88%	14	21.88%	4	6.25%
13) LP^2	64	14	**78**	17.95%	12	18.75%	6	9.38%
14) LM^1	64	14	**78**	17.95%	12	18.75%	11	17.19%
15) LM^2	64	14	**78**	17.95%	13	20.31%	10	15.63%
16) LM^3	66	9	**75**	12.00%	15	22.73%	10	15.15%
17) LM_3	58	27	**85**	31.76%	15	25.86%	6	10.34%
18) LM_2	58	25	**83**	30.12%	18	31.03%	7	12.07%
19) LM_1	53	28	**81**	34.57%	20	37.74%	8	15.09%
20) LP_2	72	9	**81**	11.11%	12	16.67%	0	0.00%
21) LP_1	81	5	**86**	5.81%	6	7.41%	3	3.70%
22) LC_1	80	5	**85**	5.88%	8	10.00%	2	2.50%
23) LI_2	78	5	**83**	6.02%	4	5.13%	0	0.00%
24) LI_1	70	10	**80**	12.50%	2	2.86%	1	1.43%
25) RI_1	70	7	**77**	9.09%	3	4.29%	1	1.43%
26) RI_2	75	7	**82**	8.54%	2	2.67%	0	0.00%
27) RC_1	79	6	**85**	7.06%	5	6.33%	2	2.53%
28) RP_1	79	7	**86**	8.14%	15	18.99%	2	2.53%
29) RP_2	82	9	**91**	9.89%	13	15.85%	2	2.44%
30) RM_1	56	31	**87**	35.63%	11	19.64%	2	3.57%
31) RM_2	64	23	**87**	26.44%	19	29.69%	6	9.38%
32) RM_3	63	23	**86**	26.74%	14	22.22%	3	4.76%

Table 9.2: Dental Pathology Frequency – Females – Permanent Dentition

Tooth #	Present	Absent	Total	% Absent	# Caries	% Caries	# Abscess	% Abscess
1) RM^3	40	12	**52**	23.08%	12	30.00%	3	7.50%
2) RM^2	48	6	**54**	11.11%	16	33.33%	3	6.25%
3) RM^1	40	13	**53**	24.53%	14	35.00%	5	12.50%
4) RP^2	47	9	**56**	16.07%	13	27.66%	2	4.26%
5) RP^1	43	16	**59**	27.12%	14	32.56%	3	6.98%
6) RC^1	55	4	**59**	6.78%	11	20.00%	2	3.64%
7) RI^2	47	7	**54**	12.96%	14	29.79%	2	4.26%
8) RI^1	46	4	**50**	8.00%	11	23.91%	3	6.52%
9) LI^1	47	6	**53**	11.32%	10	21.28%	3	6.38%
10) LI^2	49	6	**55**	10.91%	13	26.53%	2	4.08%
11) LC^1	53	3	**56**	5.36%	6	11.32%	4	7.55%
12) LP^1	45	11	**56**	19.64%	11	24.44%	3	6.67%
13) LP^2	46	7	**53**	13.21%	12	26.09%	2	4.35%
14) LM^1	41	11	**52**	21.15%	15	36.59%	7	17.07%
15) LM^2	51	5	**56**	8.93%	19	37.25%	6	11.76%
16) LM^3	44	11	**55**	20.00%	15	34.09%	2	4.55%
17) LM_3	38	19	**57**	33.33%	12	31.58%	3	7.89%
18) LM_2	41	19	**60**	31.67%	12	29.27%	7	17.07%
19) LM_1	29	25	**54**	46.30%	16	55.17%	7	24.14%
20) LP_2	51	7	**58**	12.07%	8	15.69%	3	5.88%
21) LP_1	57	4	**61**	6.56%	7	12.28%	0	0.00%
22) LC_1	59	4	**63**	6.35%	9	15.25%	2	3.39%
23) LI_2	54	5	**59**	8.47%	8	14.81%	1	1.85%
24) LI_1	57	4	**61**	6.56%	1	1.75%	1	1.75%
25) RI_1	52	5	**57**	8.77%	2	3.85%	0	0.00%
26) RI_2	56	5	**61**	8.20%	9	16.07%	1	1.79%
27) RC_1	56	7	**63**	11.11%	9	16.07%	2	3.57%
28) RP_1	52	5	**57**	8.77%	20	38.46%	5	9.62%
29) RP_2	49	9	**58**	15.52%	8	16.33%	1	2.04%
30) RM_1	32	27	**59**	45.76%	12	37.50%	6	18.75%
31) RM_2	40	20	**60**	33.33%	12	30.00%	2	5.00%
32) RM_3	39	17	**56**	30.36%	15	38.46%	3	7.69%

Table 9.3: New York African Burial Ground Total Number Carious Teeth by Sex

# of Carious Teeth	Male	*Female*	Total
0	27.1% (n=26)	15.7% (n=11)	**22.3% (n=37)**
1	11.5% (n=11)	10.0% (n=7)	**10.8% (n=18)**
2	6.3% (n=6)	10.0% (n=7)	**7.8% (n=13)**
3	5.2% (n=5)	5.7% (n=4)	**5.4% (n=9)**
4	6.3% (n=6)	12.9% (n=9)	**9.0% (n=15)**
5	10.4% (n=10)	10.0% (n=7)	**10.2% (n=17)**
6	12.5% (n=12)	7.1% (n=5)	**10.2% (n=17)**
7	7.3% (n=7)	2.9% (n=2)	**5.4% (n=9)**
8	2.1% (n=2)	7.1% (n=5)	**4.2% (n=7)**
9	2.1% (n=2)	1.4% (n=1)	**1.8% (n=3)**
10	1.0% (n=1)	4.3% (n=3)	**2.4% (n=4)**
11	3.1% (n=3)	1.4% (n=1)	**2.4% (n=4)**
12	1.0% (n=1)	4.3% (n=3)	**2.4% (n=4)**
13	2.1% (n=2)	0.0% (n=0)	**1.2% (n=2)**
14	0.0% (n=0)	0.0% (n=0)	**0.0% (n=0)**
15	1.0% (n=1)	1.4% (n=1)	**1.2% (n=2)**
16	0.0% (n=0)	2.9% (n=2)	**1.2% (n=2)**
17	1.0% (n=1)	0.0% (n=0)	**0.6% (n=1)**
18	0.0% (n=0)	1.4% (n=1)	**0.6% (n=1)**
18+	0.0% (n=0)	1.4% (n=1)	**0.6% (n=1)**
Total	**100% (N=96)**	**100% (N=70)**	**100% (N=166)**

Most adults (72.9 percent of males and 84.3 percent of females) had at least one carious tooth (Table 9.3). Historical data show that the average diet for anyone living during the Colonial Period was high in carbohydrates such as corn or wheat flour and sugar, either refined, in its raw state or in the form of molasses, which often led to caries formation (History Report, Chapter 10).

Some caries is so severe that the entire tooth is affected with inflammation and infection of the surrounding alveolar bone. The fact that many of the abscesses were untreated reflects the paucity of dental and overall medical care available to the individuals comprising the NYABG sample (Figure 9.3). Table 9.4 summarizes the mean and standard deviations for the number of carious teeth, abscessed, and lost teeth, and

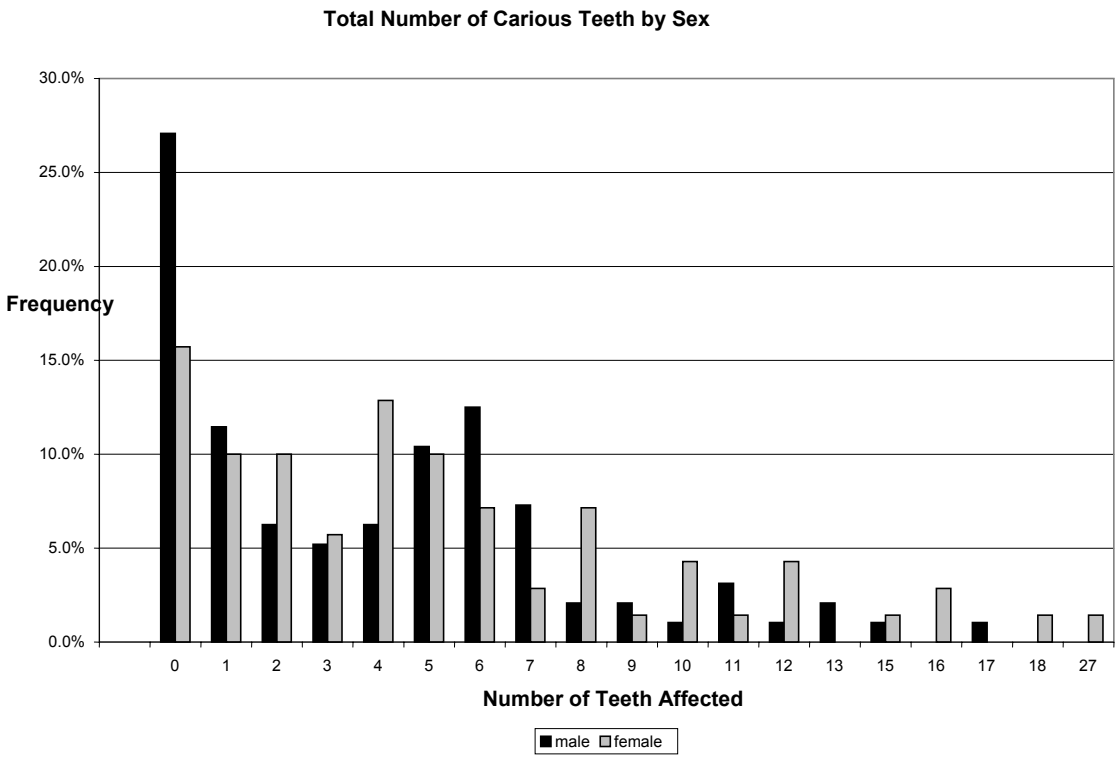

Figure 9.3: Total Number of Carious Teeth by Sex

Figure 9.4: Molar caries in a male aged 26 – 35 years (Burial 101)

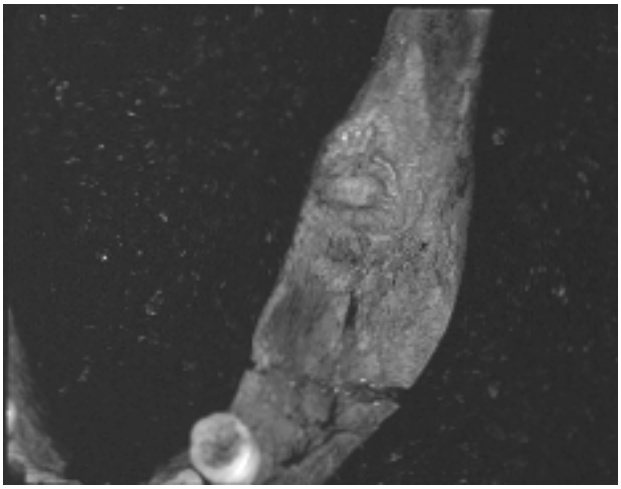

Figure 9.5: Abscessing in a female aged 25 – 35 years (Burial 266)

Figure 9.6: Caries formation in a female aged 35 – 40 years (B 107)

total pathologies, that is, the total chances of having at least one of these three conditions. As was suggested by individual tooth percents in tables 9.1 and 9.2, females have a higher average rate of carious teeth (5.2) compared to males (4.0). Females also have more lost teeth than males (4.3 vs. 3.7, respectively) and thus females have higher rates of total pathology (10.9 vs. 9.1 teeth). On average, nearly ten teeth (9.9, sd = 9.1) per permanent dentition are either lost, carious or abscessed.

Table 9.4: Dental Pathology Frequency by sex for the permanent dentition of individuals from the New York African Burial Ground

Males and Females – Permanent Dentition					
Sex		**No. Teeth Lost**	**No. Caries**	**No. Abscesses**	**Total Pathology**
Male	Value	3.7	4.0	1.5	**9.1**
N=96	St. Dev.	(5.4)	3.9	2.6	**9.0**
Female	Value	4.3	5.2	1.4	**10.9**
N=70	St. Dev.	6.2	5.1	2.7	**9.1**
Total	Value	4.0	4.5	1.4	**9.9**
N=166	St. Dev.	5.7	4.5	2.7	**9.1**

Table 9.5: Dental Pathology Frequency – Deciduous Dentition

Tooth #	**Present**	**Absent**	**Total**	**% Absent**	**# Caries**	**% Caries**	**# Abscess**	**% Abscess**
1) rm^2	67	1	**68**	1.47%	7	10.45%	1	1.49%
2) rm^1	71	2	**73**	2.74%	9	12.68%	0	0.00%
3) rc^1	64	1	**65**	1.54%	7	10.94%	0	0.00%
4) ri^2	62	3	**65**	4.62%	5	8.06%	0	0.00%
5) ri^1	59	5	**64**	7.81%	7	11.86%	0	0.00%
6) li^1	56	5	**61**	8.20%	6	10.71%	0	0.00%
7) li^2	60	2	**62**	3.23%	1	1.67%	0	0.00%
8) lc^1	64	0	**64**	0.00%	3	4.69%	0	0.00%
9) lm^1	72	1	**73**	1.37%	13	18.06%	0	0.00%
10) lm^2	71	0	**71**	0.00%	11	15.49%	0	0.00%
11) lm_2	75	0	**75**	0.00%	10	13.33%	0	0.00%
12) lm_1	83	1	**84**	1.19%	10	12.05%	0	0.00%
13) lc_1	68	1	**69**	1.45%	3	4.41%	0	0.00%
14) li_2	60	5	**65**	7.69%	1	1.67%	0	0.00%
15) li_1	56	6	**62**	9.68%	0	0.00%	0	0.00%
16) ri_1	52	6	**58**	10.34%	0	0.00%	0	0.00%
17) ri_2	57	5	**62**	8.06%	2	3.51%	0	0.00%
18) rc_1	63	2	**65**	3.08%	4	6.35%	0	0.00%
19) rm_1	78	1	**79**	1.27%	11	14.10%	1	1.28%
20) rm_2	80	0	**80**	0.00%	12	15.00%	0	0.00%

As young children are weaned onto solid foods they lose the immunological and nutritional advantages of mother's milk, which can be significant for marginally nourished populations in which the solid food diet is composed mainly of carbohydrates in the form of breads and cereal grains and either raw or processed sugars. Weaning and poor nutrition, coupled with little access or knowledge of dental care, initiates the disease process of caries and abscess formation, along with tooth loss (Figure 9.8). The frequency of dental caries and abscesses in the deciduous dentition is presented in table 9.5. Because these teeth are in the mouth for a shorter length of time, the rates of dental pathology are much lower compared to the permanent teeth. For example, only two cases of dental abscessing were found. However, many teeth do display dental cavities, including 18 percent of the upper left first deciduous molars. As with the permanent teeth, deciduous molars are more carious than single cusped deciduous teeth.

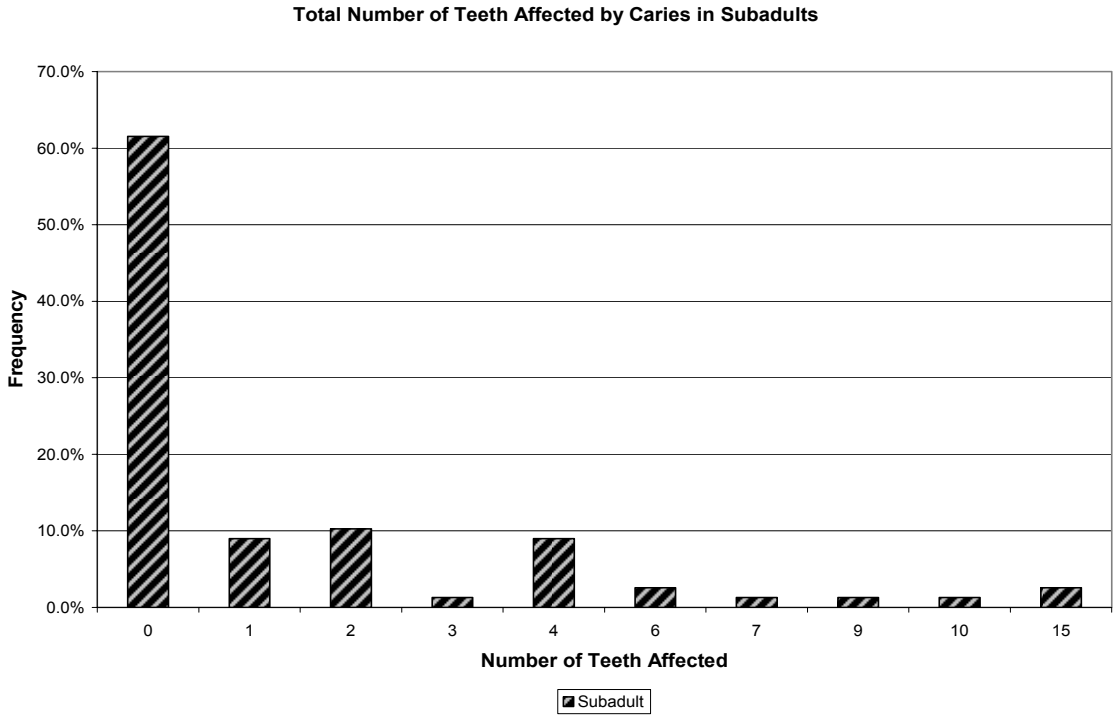

Figure 9.7: Total number of teeth affected by caries in subadults

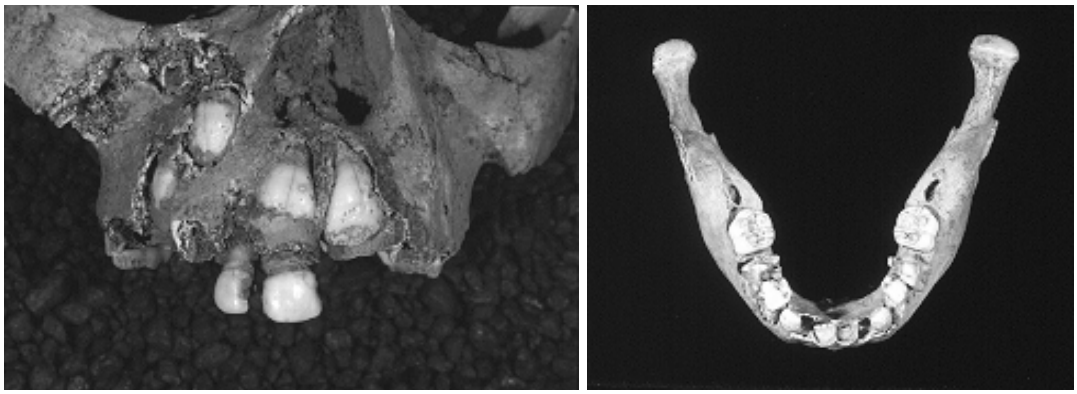

Figure 9.8: Caries, abscessing and enamel hypoplasia in a subadult aged 5 – 7 years (Burial 39)

Table 9.6: New York African Burial Ground Dental Pathology Mean Comparison with Other 18th and 19th Century Samples (Steckel and Rose 2000)

Site	No. Teeth Lost	No. Carious Teeth	No. Abscesses
African Burial Ground, NY			
Male	4	4	1.5
Female	4	5	1.4
Remley Plantation			
Male	7	2	0.5
Female	12	4	0.1
Belleview Plantation			
Male	5	6	0
Female	6	3	0.3
Charleston Elites			
Male	0	0	0.3
Female	2	1	1
FABC, Philadelphia			
Male	7	7	1
Female	5	9	1
Black Soldiers			
Male	1	2	1
Blacks, Arkansas			
Male	6	5	0.6
Female	8	4	0.4
Blacks, Texas			
Male	3	4	0.1
Female	3	4	0.1
Rochester Poorhouse			
Male	5	5	1
Female	5	6	0.9

Table 9.7: New York African Burial Dental Pathology Mean Comparison with Other 18th and 19th Century Samples (Kelly and Angel 1987)

Dental pathologies per mouth	18th Century	Catoctin	19th Century	Forensic 20th Century	NY African Burial Ground
Female	11.8 (9.8) F	11.0 (9.6) F	9.1 (11.3) F	10.3 (8.5) F	10.9 (9.1) F
	N = 12	N = 8	N = 16	N = 27	N = 70
Male	8.0 (7.7) M	14.4 (10.0) M	9.6 (8.4) M	14.1 (7.8) M	9.1 (9.0) M
	N = 16	N = 7	N = 25	N = 46	N = 96
	F + M = 9.6		F + M = 9.4	F + M = 12.8	F + M = 9.9
	N = 28		N = 41	N = 73	N = 166

The following section will compare dental pathologies in the NYABG sample with other contemporary and modern samples. Tables 9.6 and 9.7 provide a comparison of the rates of dental pathologies found in the present study compared to previously published results. Statistical comparisons are not made because of variation in methods and low sample sizes. As is true for the ABG, the general trend appears to be greater dental pathology in females than males. Caries rates are highest in the FABC sample from Philadelphia but also high in many of these samples (Table 9.6). The ABG results fall toward the high end of the middle of the range. Tooth loss is also highest in the FABC and free blacks from Arkansas, with the ABG results falling toward the middle of the range. Finally, abscess rate is greatest in the ABG (Table 9.6), which may be a reflection of poor dental care when compared to later populations, as well as a lack of access to any dental care due to the social inequalities.

The mean number of pathological teeth per mouth in the ABG versus select other samples is presented in Table 9.7. These data also suggest that the prevalence of dental pathologies in the NYABG is near the average of frequencies found at other archaeological sites. New York frequencies are high compared to other eighteenth century samples, however**.**

Genetic Dental Pathology

Genetic dental pathologies are inherited in the form of one or more alleles, although environmental stressors play a supporting role in their expression (Scott and Turner 1997). These include hypodontia (tooth agenesis), hyperdontia (supernumerary teeth), dental crowding, cleft palate, and abnormal tooth retention or exfoliation. Amelogenesis imperfecta, which produces distinctively severe enamel developmental defects, is a form of hypoplasia and hypocalcification (see Chapter 8). The following section contains examples of dental genetic anomalies from the NYABG, including dental hypodontia, dental crowding, and hyperdontia.

Subadult Dentition

One subadult, Burial 17, exhibits hypodontia of the deciduous left maxillary central incisor. Although this may be interpreted as exfoliation, there is no corroborating evidence that the tooth was ever present. This child is also afflicted with craniosynostosis, rickets, enamel hypoplasia and hypocalcification, and a cleft palate. Radiographic analysis of the maxilla and mandible also indicates substantial dental crowding of the permanent dentition.

Figure 9.9: Radiograph of incisor hypodontia in a subadult aged 4 – 6 years (Burial 17)

Dental crowding is the only genetic pathology that affects subadults with any appreciable frequency. Among subadults with intact dental arcades, 8 (9.9 percent) exhibit crowding of the deciduous teeth, especially the mandibular incisors. Additionally, through radiographic observations all but one of the eight subadults affected also exhibit dental crowding of the permanent maxillary and mandibular incisors.

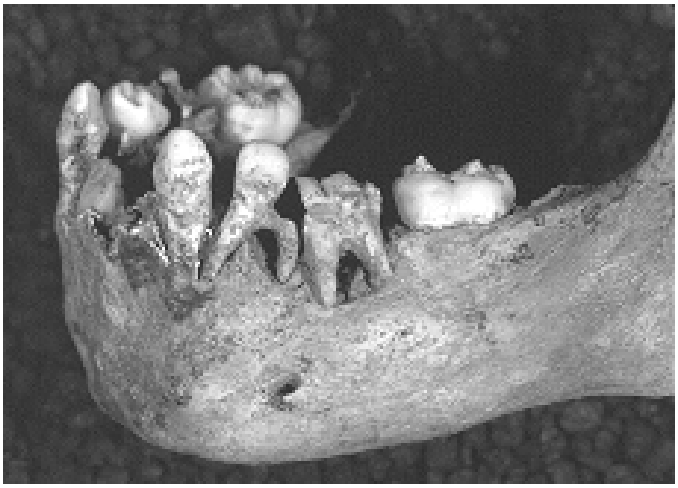

Figure 9.10: Dental crowding in a subadult aged 5 – 7 years (Burial 39)

Adult Dentition

Observable genetic dental pathologies are extremely rare in adults. Only one individual exhibits hypodontia; Burial 376, a 20-25 year old male, exhibits alveolar resorption, and his relatively young age with no tooth loss or caries formation confirms the assessment of tooth agenesis.

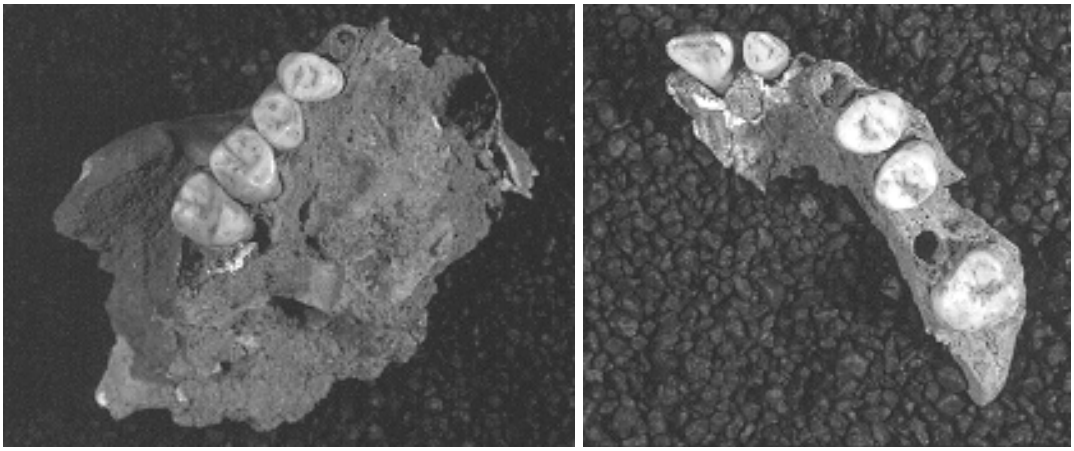

Figure 9.11: Maxillary molar agenesis in a male aged 30 – 40 years (Burial 379).

Only two individuals exhibit hyperdontia. Burial 12, a 35-40 year old female, has a supernumerary tooth at the location for the mandibular right first premolar, thereby obstructing its eruption. Burial 176, a 20-25 year old male, has a supernumerary tooth lingually adjacent to the maxillary left second premolar. The only other genetically caused dental pathology present in adults is dental crowding. Dental crowding is exhibited among 5 (0.5 percent) of the adults, specifically of the mandibular incisors.

Figure 9.12: An example of a supernumerary tooth in a female aged 35 – 45 years (Burial 12)

Conclusions

Overall, we found a high rate of tooth loss, caries and abscessed teeth. The rates of pathology, especially of dental abscesses, are high in comparison to other groups of the same period. Females generally have a higher rate of dental pathologies than males.

In addition to other hardships, it appears that individuals from the ABG had to endure the pain of dental pathologies and possibly changes in diet due to decreased ability to masticate. The overall high rate of dental pathology may reflect deficiencies in diet and dental hygiene. These results provide additional evidence of poor dietary regimens, unhealthy living conditions and lack of dental care that characterizes the quality of life for the majority of those who lived in bondage.